

USDA, Forest Service, Southern Research Station
Center for Bottomland Hardwoods Research
Headquartered in Stoneville, Mississippi
with locations in
Oxford and Starkville, Mississippi and Pineville, Louisiana
Research Work Unit SRS-4155

Annual Report to the Southern Hardwood Forest Research Group

February 16, 2005

RESEARCH MISSION:

To provide the scientific basis to manage southern bottomland hardwood and wetland forests and associated stream ecosystems for a sustained yield of forest products and other desired values.

PERSONNEL:

Dr. Ted Leininger, Project Leader/Research Plant Pathologist, Stoneville
Dr. Emile S. Gardiner, Team Leader/Research Forester, Stoneville
Dr. Mel Warren, Team Leader/Research Biologist (Aquatic Ecology), Oxford
Dr. Margaret Devall, Team Leader/Research Ecologist, Stoneville
Dr. Susie Adams, Research Fisheries Biologist, Oxford
Dr. Craig Echt, Research Geneticist, Saucier
Dr. Wendell Haag, Research Fisheries Biologist, Oxford
Dr. Paul Hamel, Research Wildlife Biologist, Stoneville
Dr. Tracy Hawkins, Research Plant Ecologist, Stoneville
Dr. Brian Roy Lockhart, Research Forester, Stoneville
Dr. J. Steven Meadows, Research Forester/Silviculturist, Stoneville
Dr. Calvin E. Meier, Research Forester/Soil Scientist, Pineville, LA
Dr. Nathan Schiff, Research Entomologist, Stoneville
Dr. Dan Wilson, Research Plant Pathologist, Stoneville
Dr. Jack Vozzo, Research Plant Physiologist, Starkville
Ms. Amy Abel, Biological Science Technician, Stoneville
Mr. Bryce Burke, Biological Science Technician, Stoneville
Ms. Penny Byler, Project Secretary, Stoneville
Ms. Amy Commens, Biological Science Technician, Oxford
Ms. Jillian Donahoo, Biological Science Technician, Starkville
Mr. Sam Franklin, Forestry Technician, Stoneville
Mr. Jim Gruhala, Biological Science Technician, Stoneville
Mr. Clifford Harwell, Hydrology Technician, Oxford
Ms. Gayle Henderson, Computer Programmer, Oxford
Ms. Cathy Jenkins, Support Services Assistant, Oxford
Ms. Gretchen Lindstrom, Biological Science Technician, Starkville
Ms. Brenda Marshall, Administrative Support Assistant, Stoneville

Ms. Frances McEwen, Office Automation Assistant, Oxford
Mr. Gordon McWhirter, Hydrology Technician, Oxford
Mr. David Murphy, Biological Science Technician, Stoneville
Ms. Charisse Oberle, Physical Science Technician, Stoneville
Mr. Danny Skojac, Forestry Technician, Stoneville
Ms. Stephanie Skojac, Biological Science Technician, Stoneville
Mr. Carl G. Smith, Biological Science Technician, Stoneville
Mr. Theran Stautz, Forestry Technician, Stoneville
Ms. Kristi Wharton, Forestry Technician, Pineville, LA
Mr. Mike Worsham, Chemist, Stoneville

Temporary Employees and Student Workers: Mr. Steven Hughes, Mr. Mickey Bland, Mr. Collin Tidwell, Ms. Jennifer Bulmanski

Volunteers: Dr. Frank Bonner, Dr. Howard Halverson, Dr. James Solomon, Mr. Ken Bonnell, Mr. Willy Shugart, and Mr. Daniel Warren

Interns: Mr Kevin Anazia (American Fisheries Society Hutton Scholar – 3 months.

SCSEP Enrollees: Ms. Ollie Everett, Ms. Alicia Newton, Ms. Mildred Miller, Mr. J.B. Conley, Mr. Billy Tanksley, Mr. James Wilkins, and Mr. Broadis Toles.

Visiting Researchers: Dr. Claudia Mettke-Hofmann and Mr. Gerhard Hofmann, from Germany visiting Paul Hamel in Stoneville.

Reassignments and Resignations: Dr. Kris Connor, Team Leader/Research Physiologist, Starkville; Ms. Beth Corbin, Forestry Technician, Stoneville; Mr. Kevin Corbin, Forestry Technician, Stoneville; Mr. Todd Marse, Biological Science Technician, Stoneville; Ms. Cynthia Strech, Biological Science Technician, Stoneville

CURRENT AND FUTURE RESEARCH:

The project currently has more than 80 active studies and 18 cooperative, collection, or interagency agreements. There are many other formal and informal agreements with cooperators to conduct research. Cooperators include faculty from universities throughout the South, elsewhere in the U. S., and other countries. Individual scientists benefit greatly from informal working agreements with a variety of forest industry cooperators. These cooperative studies have been critical in providing needed expertise, manpower, and sites for many studies. The following updates on current research include only those studies for which substantial progress was made in the last year.

Fiscal Year 2004 Technology Transfer Highlights

CBHR produced 86 publications (40 peer-reviewed).

CBHR Staff made 24 invited presentations before scientific societies, 21 presentations to lay groups, and a total of 66 presentations to scientific and professional organizations.

CBHR staff was involved in 6 short courses and 17 tours.

CBHR staff currently holds 22 leadership posts in scientific societies.

CBHR staff received several awards this year:

Dr. John Vozzo received the Secretary of Agriculture Honor Award (Plow Award) from the U.S. Department of Agriculture for “Heroism and Emergency Response (Afghanistan Reconstruction Team) for Senior Advisor for U.S. Army in Afghanistan”

Dr. Kristina Connor received a Certificate of Merit from the U.S. Department of Agriculture “For outstanding leadership in organizing and managing the 12th Biennial Southern Silviculture Conference in Biloxi, Mississippi”

Dr. Emile S. Gardiner received the “LSU Alumnus of the Year Award” from LSU Faculty of The School of Renewable Natural Resources

Aquatic and Terrestrial Fauna Team (Warren, Adams, Haag, Hamel, Commens, Harwell, McWhirter, Smith) received the “Station Director’s Award, SRS 2003, Maintaining and Enhancing Natural Resources” from the Southern Research Station for their work on the biology and ecology of aquatic and terrestrial animals, especially warm water fish, freshwater mussel, and neotropical birds. Their work has resulted in a number of peer-viewed publications.

Ms. Linda Gayle Henderson received the “Director’s Excellence in Business Operation Support Award” from the Southern Research Station for “developing, implementing, and the continuing expansion of a Distributed Budget Management Computer System used by the Center for Bottomland Hardwoods Research, Stoneville, Mississippi to track budget allocations and unit expenditures as well as manage soft money accounts.”

Research Accomplishments -- Regeneration and Reproductive Biology (Problem 1)

Providing information on regeneration and reproductive biology of bottomland hardwood species.

Dr. Kris Connor, Research Plant Physiologist
Dr. Jack Vozzo, Research Plant Physiologist
Dr. Emile Gardiner, Ecophysiologicalist
Dr. Frank Bonner, Research Plant Physiologist Emeritus

The biological basis of intolerance to desiccation of recalcitrant hardwood seeds is unknown. (SRS-4155-1001). Connor, Vozzo. While storage of orthodox seeds is a simple and routine matter, little can currently be done to promote the longevity of recalcitrant seeds since they are temperature- and/or desiccation-sensitive. The major objective of this research is to examine temperate recalcitrant seeds for measurable physical and chemical changes that may occur during desiccation and relate them to loss of seed viability. To date, it has been determined that, in the laboratory, when acorns were placed on the lab bench to dry, we saw changes in the moisture content, germination, and seed biochemistry in as few as 3 days. As drying progressed, we found that irrevocable damage to membrane lipids and protein secondary structure occurred in just 5 days. Viability for all species tested did not drop below 50% of the original level until seeds had dried at least 5 days; and relationships between axis and intact seed moisture contents and seed viability were generally strong. Axis moisture content rarely dropped below 20%.

However, we did not know if these experiments reflected what happened to acorns in the field. So, we cleared an area beneath two open-grown white oaks (*Quercus alba* L.) and marked 500 acorns each day as they dropped from the tree, a different color for each day. Marked acorns were transported to another (non-oak) tree in an area with few acorn predators and placed under the canopy. The experiment ran until acorns shed from the trees dropped below 500. At the end of the experiment, acorns were collected and tested in the laboratory for moisture content, germination, sprouting, and insect damage. We found that, unlike the laboratory experiments, germination tests on acorns left in the field gave variable results, and no distinct pattern of decreasing viability was observed. Additionally, MC of the acorns from both trees remained relatively high, never dropping below 37% on Tree 1 and 35 % on Tree 2. This is well above the MC obtained in laboratory drying experiments and, for the most part, the germination results reflect this. It is our opinion that these results reflect the moderating effects of the rainfall that occurred throughout the experiment. Although 3x as much rainfall occurred over the collection period of Tree 1, each tree's collection period had 8 days where some precipitation occurred, and maximum daily relative humidity never fell below 90%. We believe that declines in acorn viability are more a reflection of problems in the germination cabinets than of physical changes. We experienced some difficulty with moisture accumulation on the trays and resulting mold growth. It is our opinion that

germination would have been uniformly high if the moisture wicking problems could have been controlled and mold growth reduced. We intend to continue these experiments in hopes of encountering years when a bumper crop of acorns coincides with dry conditions during shed.

Other research is focusing on mobile proton distribution of two subspecies of hydrogen atoms (free-molecular water and long-chain fats), which shows paths and pools of stored metabolites during storage and germination challenges. Digital imaging of both proton distributions indicates a visual pattern to follow seed treatments. Also, pathologists have taken interest in these techniques to allow water movement indexing responding to infectious agents, viz fungi. Invited posters and presentations of this work have been presented at 3 meetings (in Uzbekistan, Venezuela, and China) and an MRI protocol has been developed. In addition, new technologies (MRS and cryoprobes) are now available to continue the imaging research. Recent adaptations for nitric oxide synthase in plant sciences have promising potential for messenger-molecular physiology, specifically, the qualitative analyses for β synthase which is present in tree seeds. Work on this aspect of seed biology has been initiated this year.

Woody Plant Seed Manual. Bonner. The revision to this authoritative reference is under the editorial leadership of Dr. Bonner, as a volunteer since retirement. The final edited version is near completion and the manual should be published in 2005 (we all hope).

Underplanting beneath a partial overstory to establish cherrybark oak regeneration in a minor bottom of southwestern Arkansas. (SRS-4155-1402). Gardiner and Yeiser. This study was initiated in a mixed, bottomland hardwood stand near Beirne, AR to 1) test the importance of understory competition control and season of application to establishment and growth of underplanted oak seedlings, 2) compare the suitability of two seedling stock types for underplanting, and 3) test for interacting effects of competition control and stock type on establishment and growth of underplanted oak seedlings. In addition, this study will provide 1) an evaluation of the effects of partial canopy removal on the light environment in the understory of a mixed hardwood stand, and 2) an evaluation of the impact of vegetation control on establishment and growth of natural regeneration and woody species diversity under a partial canopy. To meet the stated objectives, this experiment was designed with 3 levels of understory competition control (none, Spring application, Fall application) and 2 levels of seedling stock type (seedlings with 4 or more lateral roots greater than 1 mm in diameter and seedlings with fewer than 4 lateral roots greater than 1 mm in diameter). Partial cutting in the overstory and midstory reduced stand stocking to 35% in the fall of 1996. Herbicide applications were applied in the spring and fall of 1997. The stand was underplanted in March 1998. Initial responses by natural regeneration and understory biomass were sampled in the fall of 1997 and 1998. Initial responses by underplanted seedlings were measured in the fall of 1998. First year results were reported at the 10th Biennial Southern Silvicultural Research Conference in February 1999. Second year post-planting data were collected in the fall of 1999 and third year post-planting data were

collected in the fall of 2000. Residual overstory trees were removed in the fall of 2000 to release regeneration. Third year results were presented at the Fourth International Conference on Forest Vegetation Management, June 2002. A manuscript that presents findings through year 3 is currently in revision for publication in the journal *New Forests*. Measurements on the development of artificial and natural regeneration are being continued on an annual basis.

Partial cutting to facilitate establishment of artificial Nuttall oak regeneration in the Mississippi Delta. (SRS-4155-1403). Gardiner. This study was initiated in a mixed, bottomland hardwood stand near Anguilla, MS to 1) compare the suitability of three different stand stocking levels for establishment and growth of underplanted oak seedlings, 2) test the importance of competition control to establishment and growth of artificial oak regeneration, and 3) test for interacting effects of stand stocking level and competition control on establishment and growth of artificial oak regeneration. Additional information to be gained from this study will include 1) the impact of competition control on growth of natural regeneration and woody species diversity under each stand stocking level, and 2) an evaluation of the effects of various canopy removals on the understory light environment in a mixed, bottomland hardwood stand. To meet the stated objectives, this study was designed with three levels of stand stocking (0%, 25%, 50%), and two levels of competition control (none, spot applications around artificial regeneration). Pre-treatment sampling of natural regeneration, understory biomass, and light levels were completed in the summer of 1997. Partial cutting in the overstory and midstory were completed in the fall of 1998. Underplanting was finished in early 1999 while herbicide treatments were applied in May 1999. First through third-year measurements on survival and growth of artificial regeneration were completed in 1999 and 2000, 2000 and 2001. Third year results were presented at the Twelfth Biennial Southern Silvicultural Research Conference, February 2003. A manuscript that documents biomass accumulation of the underplanted seedlings in relation to stand structure is currently in preparation.

Physiology, morphology, and growth of Nuttall oak artificial regeneration beneath an eastern cottonwood nurse crop. (SRS-4155-1406). Gardiner, Schweitzer, and Stanturf. Silvicultural systems involving the use of eastern cottonwood as a nurse crop for establishment of other bottomland hardwood species are currently under evaluation in the Mississippi Delta. Cottonwood may be a suitable nurse for species such as Nuttall oak because of its ability to grow on similar sites, relatively open crown habit, and economic value. Therefore, a study has been initiated to determine how Nuttall oak seedlings function beneath an eastern cottonwood nurse crop. In March 1995, four eastern cottonwood clones were planted in three, 5-acre replicates on abandoned agricultural land in Sharkey County, MS. Cuttings were planted on 12 x 12 foot spacing. Following the second growing season (Winter 1996/97), 1-0 Nuttall oak seedlings were inter-planted between every other cottonwood row in the plantation. Physiology (photosynthesis and transpiration), morphology (biomass accumulation), and growth (height and diameter) were studied on the interplanted Nuttall oak seedlings. Seedling responses are currently being evaluated in

relation to environmental variables (photosynthetically active radiation, temperature, and soil moisture) measured beneath the cottonwood canopy. Initial results indicate that light availability beneath the cottonwood nurse crop may be sufficient to maintain height and diameter growth of Nuttall oak seedlings. However, carbon assimilation by Nuttall oak may be sub-optimal on degraded sites where intensive row cropping has depleted soil nitrogen. Findings on biomass distribution of interplanted oak seedlings were presented at the International Conference on Restoration of Boreal and Temperate Forests, April 2002, and were published in the journal *Restoration Ecology* in December 2004.

Research Accomplishments -- Stand Development and Forest Health (Problem 2)

Providing the scientific expertise to address stand management and forest health concerns that enable a sustainable supply of multiple resources from bottomland hardwood and associated upland ecosystems.

Dr. Ted Leininger, Research Plant Pathologist
Dr. Dan Wilson, Research Plant Pathologist
Dr. Nathan Schiff, Research Entomologist
Dr. Steve Meadows, Silviculturist
Dr. James Solomon, Research Entomologist Emeritus

Investigations and control of microbes causing Sycamore dieback and decline in commercial plantations. (Study SRS-4155-2407) Leininger, Schiff, and Wilson. Some forest industries remain interested in growing hardwoods in upland plantations using irrigation and liquid fertilizer to increase growth rates. One of these species, American sycamore (*Platanus occidentalis*) grows rapidly and has good pulping characteristics for manufacturing paper. Unfortunately, when sycamores are grown on upland sites in plantations it is susceptible to dieback and decline, which can be caused by one or more fungi and a bacterium, acting alone or together, with environmental conditions. A laboratory study (Wilson and Leininger) examined the response of *Ceratocystis fimbriata* f.sp. *platani* and *Botryosphaeria rhodina*, two fungi associated with sycamore dieback, to five triazole fungicides. The fungicides showed good ability to reduce the growth of each fungi growing on agar medium. This information, which may be useful for field trials in which triazole fungicides are injected into the irrigation water of sycamore trees growing in a plantation, is being prepared for publication in a peer-reviewed journal.

Leininger has worked in the past with MeadWestvaco and Boise Corporation to identify sycamore clones with tolerance to *Xylella fastidiosa*, the causal agent of bacterial leaf scorch. Hundreds of ELISA tests were run monthly from May through November 2001, 2002, 2003, and 2004 to identify sycamores with bacterial leaf scorch disease. The continued success of

this study, in the coming years, will depend on finding cooperators to aid in determining genetic tolerance in the clones.

Schiff and Leininger completed a study that indicates strongly that the glassy-winged sharpshooter, a common xylem-feeding insect in the southeast, can transmit *Xylella fastidiosa* from diseased to healthy sycamores. PCR tests are underway to determine the presence or absence of the bacterium in insects used during the study, and from other collections. A manuscript is being prepared.

Detecting wetwood bacteria in red oaks. Leininger. This cooperative research with SRS-4702 in Blacksburg, VA is a continuation of an effort begun in 1994 initially to identify bacteria that cause wetwood in red oaks and to develop an immunological assay technique to detect the presence of wetwood. A simple, accurate system to detect wetwood in living oaks and sawn oak lumber would greatly assist field foresters and mill managers. The ideal detection system would identify wetwood trees in the forest before they were selected for harvest. An accurate prediction of site risk factors would allow silvicultural manipulation to reduce the incidence of affected trees. The effort is now focused on using ultrasound to detect wetwood, as well as heartrot and voids, in various hardwood species. USFS cooperators are working with a commercial engineering firm to test an ultrasound detector that causes minimal damage to the tree being examined. Research in 2003 involved an FS cooperator in RWU-4702, who measured ultrasound signal response in wetwood and healthy hardwood samples. A manuscript has been accepted for publication in the *Forest Products Journal* and should be in print later this year. (Kabir, M.F., Leininger, T.D., Araman, P.A. 200_. Detection of Wetwood by Ultrasonic Signal Propagation.)

Willow oak decline on flooded sites in D'Arbonne NWR, LA (SRS-4155-2406) Leininger. A study was installed in fall 1997 to examine the factors contributing to the dieback and mortality of willow oaks on the D'Arbonne NWR north of Monroe, LA. A hypothesis is that flooding on stands through June of most years, in conjunction with different soil types, is causing variations in levels of dieback and mortality. Variables to be measured in study plots on the two soil types of interest include; annual growth, crown condition, occurrence of diseases, occurrence of insect borers, and mortality. The efficacy of intermediate thinning in ameliorating the dieback will be examined by measuring these variables in stands with or without thinning. Crown condition data were collected again in August 1999. Two of the three sites were logged in fall 2000; the third site was logged in fall 2001. Work was done in 2002 to reestablish plot boundary markers following harvests. The first post-harvest crown condition and growth measurements were made in summer 2004. Tree growth chronologies from cores collected in 1998 are being analyzed by Margaret Devall.

Roles of Wood-boring Wasps as Vectors of Wood Decay Fungi. (SRS-4155-2801). Schiff, Wilson. Woodwasps are primitive Hymenoptera that use wood decay fungi to attack stressed and weakened trees. There are approximately 200 species worldwide and approximately 30 species in the United States that attack hardwoods and conifers. There are two exotic species

that are of extra concern. *Eriotremex formosanus* is native to Southeast Asia and attacks hardwoods especially oaks. It was first noticed in the 1970's and it is now widespread throughout the South. *Sirex noctilio* is a European species that attacks Monterey pines wherever they are grown and there is some concern that it will enter the US from South America and become a pest of loblolly pine. Woodwasps in the Western United States are attracted to forest fires where their larvae and symbiotic fungi can devalue salvage timber. We are interested in identifying the fungal symbionts used by the woodwasps, measuring damage to trees and wood, identifying chemically mediated behaviors such as oviposition and exploring novel ways to control the wasps and fungi. Recently we have completed several studies including a large wood decay study where we measured consumption of several different hardwood species by the symbiotic fungi associated with hardwood woodwasps, a study of somatic antagonism by the same fungi, a behavioral study demonstrating that oviposition is mediated by wood volatiles, an EAD study of woodwasp olfaction and a survey of insects including woodwasps that are associated with forest fires. Several manuscripts are in preparation. This year we are starting to identify accumulated fungal isolates using DNA fingerprinting, planning a second wood decay study and some chemical characterization of the wood decay fungi and continuing the behavioral studies. Since the last report, Schiff published a paper with David Smith of the Systematic Entomology Lab on woodwasp systematics and biology and presented two invited talks. We have consulted with Martin McKenzie in West Virginia and there are plans of a collaboration to make an interactive internet based key to the woodwasps. We have identified woodwasps for groups in Colorado, Florida and the Oregon Department of Agriculture. Internationally, Schiff met with Bernard Slippers who works on *Sirex noctilio* and its fungal symbiont in South Africa, Harold Schmitz and his group from Germany that are interested in insects that go to forest fires and John Jennings who is interested in woodwasps in Australia. Jennings, Smith and Schiff will collaborate on woodwasps found in Australia and a key to worldwide genera. Jennings and Schiff submitted a small grant to "Australian Biological Resources" to cover costs. Schiff was asked to be on a Ph. D. committee for a student at the University of Mississippi studying insect-mediated lignin degradation and was elected to an adjunct faculty position.

Use of aromascan detector for the identification and discrimination of plant pathogenic microbes causing lumber defects in standing timber. (SRS-4155-2601) Wilson, Oberle, Schiff. Research conducted to develop new ways to detect microbes causing lumber defects of hardwoods in bottomlands forests continues to provide new information. We have developed a largely nondestructive method for detecting the presence of microbes causing such diseases as bacterial wetwood in hardwoods, using Conductive Polymer Analysis (CPA), a type of Electronic Aroma Detection (EAD) technology, based on the production and release of unique mixtures of chemicals by the microbes themselves in infested wood cores. So far, this new technology represents an entirely new method for the diagnosis of tree diseases. Virtually all diseases tested so far have yielded specific and unique aroma signatures that have allowed the effective diagnosis of specific diseases found in the database. Early diagnosis of these diseases in the field (before timber harvest), in the lumber

yard before processing, or during the cutting phase prior to drying is essential to preclude economic losses. With this method, we were able to detect wetwood in increment wood cores of several oak species. We established that lumber cut from wetwood logs exhibited considerable defects and deformations that resulted in degradates. The most common lumber defects were ring shakes, collapse and cupping of board surfaces, and discoloration. Oak infested with bacterial wetwood has a very strong pungent and acidic odor similar to butyric acid. The electronic aroma signature patterns (EASPs) derived from oak cores often produced sensor outputs that produced negative signals, below the baseline, that are indicative of carboxylic acids which bind firmly to certain sensors. These unique EASPs were different from any other aroma signatures produce by wetwood bacteria in other hardwood species, including cottonwood, hickory, and American elm as well as in bald cypress (a deciduous conifer) in bottomland forests. Results this past year have indicated that CPA is a reliable diagnostic tool for the detection of bacterial wetwood in *Quercus* species (oaks) using volatiles from inner sapwood cores. Both healthy and infected cores from these species were identified with high levels of confidence based on differences in EASPs. We are also developing applications of this new technology for the identification of tree species from their unique volatiles released from increment wood cores. Further research is planned also to develop these methods to detect specific insect pests. Research so far in this area has indicated that these methods can distinguish between subterranean termites. Ultimately, the method will be refined to detect these individual species within wood in service, such as in the walls of residential homes. Early detection will facilitate control of these pests before significant damage has been done.

Thinning red oak-sweetgum stands on minor streambottom sites. I. Aliceville, Alabama (SRS-4155-2208a). Meadows. This study is the first in a series of thinning studies in red oak-sweetgum stands on minor streambottom sites across the South. All studies in the series utilize the same study design, treatments, and methods. Long-term objectives (for the entire series of studies) include (1) to develop practical guidelines for the intermediate management of bottomland hardwood stands, (2) to develop a growth and yield model for managed stands of bottomland hardwoods, and (3) to test the applicability of various levels of recommended residual stocking, including that proposed by John Putnam in 1960. Short-term objectives (for each individual study) include (1) to determine the effects of various levels of thinning on stand growth, development, and yield, and (2) to determine the growth and bole quality responses of individual trees to various levels of thinning. Treatments in all studies in the series are (1) no thinning, (2) light thinning to 70-75 percent residual stocking, (3) heavy thinning to 50-55 percent residual stocking, and (4) B-line thinning to Putnam's recommended residual density following partial cutting in bottomland hardwoods. This first study in the series was established in late summer 1994 on a bottomland tract near Aliceville, Alabama. Our cooperator in this study is Gulf States Paper Corporation. The thinning operation consisted of a combination of low thinning and improvement cutting, in which the objective was to remove most of the pulpwood-sized trees as well as sawtimber-sized trees that were damaged, diseased, of poor bole quality, or

of an undesirable species. Hardwood tree classes were used to set the cutting priority. Prior to thinning, stand density averaged 196 trees and 121 square feet of basal area per acre. Quadratic mean diameter of the stand (among trees greater than or equal to 3.5 inches dbh) was 10.7 inches. Diameter of dominant and codominant trees in this 60-65-year-old, red oak-sweetgum stand averaged about 17-18 inches. Stocking averaged 107 percent across the 24-acre study area. Light thinning reduced stand density to 83 trees and 82 square feet of basal area per acre, increased quadratic mean diameter to 13.5 inches, and reduced stocking to 69 percent. Heavy thinning reduced stand density to 49 trees and 64 square feet of basal area per acre, increased quadratic mean diameter to 15.5 inches, and reduced stocking to 52 percent. B-line thinning reduced stand density to 65 trees and 86 square feet of basal area per acre, increased quadratic mean diameter to 15.6 inches, and reduced stocking to 70 percent. Fourth-year results were published in the Proceedings of the Eleventh Biennial Southern Silvicultural Research Conference. We took 9th-year measurements in March 2004. Preliminary analysis of these data indicate that stand-level growth during the 9 years since thinning has been moderate, with relatively modest increases in basal area (about 8-11 square feet of basal area per acre) observed in the thinned areas. All thinning treatments produced moderate increases in diameter growth of individual trees, when averaged across all species. Of particular interest were dominant and codominant red oaks, in which only small gains were made in diameter growth in response to the three thinning levels. Nine-year diameter growth of dominant and codominant red oaks averaged 2.6 to 2.7 inches across the three levels of thinning, as compared to 2.2 inches in the unthinned stand. Thinning had little or no effect on the production of new epicormic branches on the butt logs of residual trees, even among red oaks, which are generally considered to be susceptible to the production of epicormic branches following disturbance. Residual dominant and codominant red oaks in the thinned stands averaged 1.4 to 2.2 new epicormic branches, as compared to 0.5 new branches on the butt logs of dominant and codominant red oaks in the unthinned stand. These minor increases in the number of epicormic branches were not large enough to affect log grade of sawtimber-sized trees. Production of new epicormic branches varied widely across crown classes and, to a lesser extent, among some of the other species. We plan to take 12th-year measurements during the winter of 2006-07.

Thinning red oak-sweetgum stands on minor streambottom sites. II. Demopolis, Alabama (SRS-4155-2208b). Meadows. This study is the second in a series of thinning studies in red oak-sweetgum stands on minor streambottom sites across the South. All studies in the series utilize the same study design, treatments, and methods, as described above. This study was established in late summer 1995 on a bottomland tract near Demopolis, Alabama. Our cooperator in this study is Gulf States Paper Corporation. Prior to thinning, stand density averaged 195 trees and 129 square feet of basal area per acre. Quadratic mean diameter of the stand (among trees greater than or equal to 3.5 inches dbh) was 11.0 inches. Diameter of dominant and codominant trees in this 65-70-year-old, red oak-sweetgum stand averaged about 18-19 inches. Stocking averaged 109

percent. Light thinning reduced stand density to 72 trees and 88 square feet of basal area per acre, increased quadratic mean diameter to 15.0 inches, and reduced stocking to 72 percent. Heavy thinning reduced stand density to 50 trees and 67 square feet of basal area per acre, increased quadratic mean diameter to 15.6 inches, and reduced stocking to 54 percent. Putnam's B-line thinning reduced stand density to 61 trees and 89 square feet of basal area per acre, increased quadratic mean diameter to 16.3 inches, and reduced stocking to 72 percent. Unthinned plots averaged 163 trees and 129 square feet of basal area per acre, with a quadratic mean diameter of 12.1 inches and a stocking of 108 percent.

We took 9th-year measurements in October 2004. Both stand-level and individual-tree-level growth responses to thinning were considerably greater on this relatively high-quality site than those observed on the medium-quality site at Aliceville, as described above. Increases in stand basal area ranged from 18 to 21 square feet per acre across the three thinned areas during the 9 years since thinning, as compared to about 13 square feet per acre of basal area growth in the unthinned area. Diameter growth of individual trees was significantly improved by all thinning treatments. As in the Aliceville study, diameter growth response of red oaks was greater than for other species. Nine-year diameter growth of dominant and codominant red oaks averaged from 2.7 to 3.1 inches in the thinned areas, as compared to 2.1 inches in the unthinned area. Production of new epicormic branches on the butt logs of residual trees increased during the first 9 years following thinning, but varied widely among both species and crown classes. Residual dominant and codominant red oaks in the thinned stands averaged 0.8 to 3.4 new epicormic branches, as compared to 0.6 new branches on the butt logs of dominant and codominant red oaks in the unthinned stand. These minor increases in the number of epicormic branches did not affect log grade of sawtimber-sized trees. The study site was severely damaged by Hurricane Ivan in September 2004, but we were able to collect 9th-year data in October 2004. Because damage to residual trees was so extensive, we will close this study in 2005.

Thinning red oak-sweetgum stands on minor streambottom sites. IV. Diboll, Texas (SRS-4155-2208d). Meadows. This study is the fourth in the series of thinning studies in red oak-sweetgum stands on minor streambottom sites across the South. All studies in the series utilize the same study design, treatments, and methods, as described above. This fourth study was established in autumn 2000 on a bottomland tract along the Neches River near Diboll, Texas. Our cooperators in this study are Temple-Inland Forest Products Corporation. Due to space limitations at the study site, the B-line thinning treatment was not included in this study. Prior to thinning, stand density averaged 147 trees and 119 square feet of basal area per acre. Quadratic mean diameter of the stand (among trees greater than or equal to 3.5 inches dbh) was 12.2 inches. Diameter of dominant and codominant trees in this 85-year-old, red oak-sweetgum stand averaged about 22 inches. Stocking averaged 101 percent across this older stand. Light thinning reduced stand density to 48 trees and 88 square feet of basal area per acre, increased quadratic mean diameter to 18.4 inches, and reduced stocking to 70 percent. Heavy thinning reduced stand density to 33 trees and 66 square feet of basal area per acre, increased quadratic mean

diameter to 19.2 inches, and reduced stocking to 52 percent. The stand was thinned in October 2000 and we took 3rd-year measurements in March 2004. Stand basal area growth was minimal across all three treatments during the 3 years after thinning. Both levels of thinning increased diameter growth of individual trees, when averaged across all species. Three-year diameter growth of residual trees averaged 0.6 and 0.5 inches following heavy and light thinning, respectively, while diameter growth of trees in the unthinned stand averaged 0.2 inches. As in the other studies in this series, diameter growth response of red oaks was greater than for all other species. Dominant and codominant red oaks averaged 0.9 to 1.1 inches of diameter growth in response to the two levels of thinning, as compared to 0.7 inches of diameter growth in the unthinned stand. Thinning had little or no effect on the production of new epicormic branches on the butt logs of residual trees, even among red oaks, which are generally considered to be susceptible to the production of epicormic branches following disturbance. Dominant and codominant red oaks in the thinned areas averaged 1.0 to 1.4 new epicormic branches, as compared to 0.4 new branches on the butt logs of dominant and codominant red oaks in the unthinned stand. We plan to take 4th-year measurements in February or March of 2005.

Stand quality management of southern hardwood forests. I. Red River Wildlife Management Area, Louisiana (SRS-4155-2211a). Meadows and Skojac. We recently received funding in the form of grants from Gulf States Paper Corporation, Louisiana Department of Wildlife and Fisheries, and Temple-Inland Forest Products Corporation, as well as a matching grant from the U.S. Forest Service (total of \$40,000) to initiate a new series of thinning studies in hardwood stands across the South to investigate the effectiveness of a new tree classification system as a tool to implement our guiding concept of stand quality management. We modified, strengthened, and expanded the existing hardwood tree classification system developed by John Putnam in 1960 to create a new hardwood tree classification system that consists of five classes used only for sawtimber-sized trees: (1) preferred growing stock, (2) desirable growing stock, (3) acceptable growing stock, (4) cutting stock, and (5) cull stock; and two classes used only for poletimber-sized trees: (1) superior poletimber stock, and (2) inferior poletimber stock. We also recently developed and now advocate the concept of **stand quality management** rather than stand density management as the overriding factor in planning and executing partial cuttings in southern hardwood forests. In its simplest terms, stand quality management can be expressed as “If it’s a poor tree, cut it; if it’s a good tree, leave it!” Less emphasis is placed on the idea that hardwood stands must be cut to some pre-determined, quantitative level of residual stand density. Instead, individual-tree quality dictates which trees will be cut and which trees will be left. As long as residual stand density falls within fairly broad limits, prescriptions and marking rules for partial cuttings in southern hardwood stands should be based on tree quality alone. Our new tree classification system is a tool that can be used to segregate different levels of tree quality into distinct tree classes. The new tree classification system can thus be used to define the residual component for a variety of partial cutting prescriptions. This new series of

thinning studies will consist of 8-10 individual studies installed over the next 5 years. All studies within the series will utilize the same study design, methods, and treatments. Each individual study within the series will be designed to determine the effects of four thinning prescriptions, as defined by the new tree classification system under the guiding concept of stand quality management, on both stand-level and individual-tree-level growth, quality, and value. Results from the entire series of studies will be combined to develop a research-based conceptual model that can be used to provide guidance to resource managers in the selection of the most appropriate thinning prescription to use in southern hardwood stands with different levels of initial quality and at different stages of stand development. In all individual studies within this series of thinning studies, the new tree classification system will be used to define the residual-tree component for each of the following thinning treatments: (1) no thinning, (2) acceptable growing stock with residual superior poletimber, (3) acceptable growing stock with no residual poletimber, (4) desirable growing stock with residual superior poletimber, and (5) desirable growing stock with no residual poletimber. The first study in this new series of thinning studies was installed during the summer of 2004 in an approximately 35-year-old water oak plantation at the Red River Wildlife Management Area near Shaw, Louisiana. Our cooperator in this first study is the Louisiana Department of Wildlife and Fisheries. Prior to thinning, stand density averaged 122 trees and 101 square feet of basal area per acre. Quadratic mean diameter of the stand (among trees greater than or equal to 5.5 inches dbh) was 12.4 inches. Thinning treatments were applied during the autumn of 2004. We plan to take 1st-year measurements during the winter of 2005-06.

Diameter and bole quality responses of residual hardwood poletimber to thinning in sawtimber stands (SRS-4155-????). Skojac and Meadows. This study serves as Danny Skojac's thesis research for his M.S. degree in hardwood silviculture at Mississippi State University under the direction of Dr. Andrew Ezell. There is little documentation that addresses the benefits of retention of poletimber trees following thinning in sawtimber-sized stands. The question remains as to whether residual poletimber trees can grow at a satisfactory rate and develop high-quality boles while in competition with larger residual sawtimber trees following thinning. In other words, it is not known whether the diameter and bole quality responses of poletimber trees warrant their retention in commercially thinned sawtimber-sized stands. This study is designed to address the following objectives: (1) to assess and compare the diameter growth and bole quality responses of poletimber trees to various levels of thinning in an even-aged sawtimber stand of red oak-sweetgum, and (2) to assess and compare any differential response between Superior Poletimber Stock and Inferior Poletimber Stock to the various levels of thinning. The study site is located on Barksdale Air Force Base near Bossier City, Louisiana. Our cooperator in this study is the U.S. Air Force. The study area supports a mid-rotation, small-sawtimber stand of medium initial stand quality that is dominated by red oak and sweetgum. Predominant red oaks are water and willow oaks, but there are some scattered cherrybark and Nuttall oaks. Sweetgum is the primary non-oak species, but there are also numerous pecans and

American elms scattered throughout the stand. A new tree classification system developed by Meadows and Skojac was used to define the residual-tree component for each of the following thinning treatments: (1) no thinning, (2) desirable growing stock with residual superior poletimber, (3) desirable growing stock with residual inferior poletimber, (4) acceptable growing stock with residual superior poletimber, and (5) acceptable growing stock with residual inferior poletimber. Prior to thinning, stand density averaged 120 trees and 110 square feet of basal area per acre. Quadratic mean diameter of the stand (among trees greater than or equal to 5.5 inches dbh) was 12.9 inches. Stocking averaged 93 percent across the 30-acre study area. Red oaks accounted for 30 percent of the trees and 47 percent of the basal area of the stand. Sweetgum accounted for 51 percent of the trees and 39 percent of the basal area. Quadratic mean diameter of the red oak component of the stand was 16.1 inches, whereas quadratic mean diameter of the sweetgum component of the stand was only 11.2 inches. Prior to thinning, there were an average of 6.0 Superior Poletimber trees per acre, of which 50 percent were sweetgum and 42 percent were red oak. Superior Poletimber trees averaged 10.0 inches in diameter and had 3.5 epicormic branches on the butt log. In contrast, there were 27.7 Inferior Poletimber trees per acre, of which 59 percent were sweetgum, 19 percent were red oak, and 22 percent were other species such as American elm, pecan, and black cherry. Inferior Poletimber trees averaged 8.2 inches in diameter and had 8.1 epicormic branches on the butt log. Thinning treatments were applied to the study area in December 2003. First-year measurements were taken in November 2004. Danny is currently analyzing the data and will publish these first-year results in his thesis. However, some general observations can be made. Thinning improved diameter growth of both Superior Poletimber trees and Inferior Poletimber trees, with larger diameter-growth responses observed among Superior Poletimber trees. Thinning also increased the number of new epicormic branches along the butt log of trees in both poletimber tree classes, with larger increases observed among Superior Poletimber trees. However, Inferior Poletimber trees had many more total epicormic branches along the butt log than did Superior Poletimber trees. In general, most of the new epicormic branches produced by Superior Poletimber trees were found along the upper portion of the butt log, whereas new epicormic branches produced by Inferior Poletimber trees were found evenly distributed along the butt log. New epicormic branches were more-or-less evenly distributed across the cardinal-direction faces of the boles of both Superior Poletimber trees and Inferior Poletimber trees. For trees of both poletimber tree classes, small epicormic branches (less than 1 foot long) were ephemeral, whereas larger epicormic branches (1-3 feet long) were more persistent. In general, more than 50 percent of these smaller branches died during the first year, whereas about 75 percent of the larger branches remained alive. The ephemeral nature of these small branches was especially true in sweetgum and the persistent nature of the larger branches was especially true in red oaks. We plan to take 2nd-year measurements during the winter of 2005-06.

Research Accomplishments -- Terrestrial and Aquatic Fauna (Problem 3)

Expanding the ability to manage simultaneously for biodiversity maintenance and multiple resource use.

Dr. Mel Warren, Research Biologist, (Aquatic Ecology)

Dr. Susie Adams, Research Fisheries Biologist

Dr. Wendell Haag, Research Fisheries Biologist

Dr. Paul Hamel, Research Wildlife Biologist

Fish and Fish Habitat Survey of the National Forests in Mississippi. (Problem 3) Warren, Haag, Adams. Mississippi National Forests have expressed a need for development of standard protocols for assessing fish and fish habitat. The goals of the protocol are to provide National Forest resource planners, managers, and decision-makers with: (1) an inventory of fishes; (2) information on the community structure of stream fishes and the condition of fish habitat; (3) a repeatable assessment method to evaluate the effectiveness of forest best management practices on stream fish communities and fish habitat; and (4) a monitoring tool that provides a means to assess cumulative effects of watershed activities on stream conditions and to compare streams and stream fish communities across the Forest. A survey protocol was developed in spring of 1999 and tested at over 79 stream sites in summer 1999 in the Holly Springs National Forest. In summers 2000-2003 the protocol was applied to 299 additional stream sites selected on the Desoto, Holly Springs, Homochitto, Chickasawhay, Bienville, Tombigbee, and Yalobusha units and yielded about 110 freshwater fish species, over half the known fauna of Mississippi. By applying the protocol over several years throughout Mississippi National Forests, a near comprehensive inventory and stream health assessment was accomplished. The protocol consists of quantitative (catch-per-unit-effort) fish sampling and physical habitat inventory with stream reaches located from headwaters to mouth within a watershed. Habitat data for each surveyed site included a longitudinal array of transects describing width, depth, water velocity, substrate type, and woody debris as well as riparian condition (e.g., canopy cover, bank stability, height, and vegetation). Freshwater mussels and crayfish databases are being developed for inventory and monitoring of these animals in Mississippi National Forests. A GIS-linked database developed by Ms. Gayle Henderson, CBHR computer programmer, is being used and refined for queries, data input, storage, and retrieval. This is the first systematic, quantitative fish and fish habitat inventory for National Forest lands in Mississippi and the first extensive inventory for freshwater mussels and crayfish on the Forests. The physical data and fish samples are being analyzed in the context of an Index of Biotic Integrity. The information is also being used to assist MsNF in developing a watershed condition index and a coarse filter for aquatic species viability as part of the new Forest Plan. Researchers at Mississippi State University, under

USDA contract, are applying the data on the Bienville National Forest in a Bayesian analysis of impacts of reservoir construction on freshwater fishes and fish communities. Watershed land-use information coupled with site-specific habitat and fish community information has yielded a powerful tool to assess the effectiveness of BMPs practiced by Mississippi National Forests, and address the pressing questions of the viability of populations of fishes and other aquatic organisms on the forests.

Distribution, diversity, and abundance of upland stream fishes under variable environmental conditions. (Problem 3) Warren with Taylor, Fiorillo, Williams, Thomas, Holder. We examined the effects of stream size and variation in flow regime on spatial and temporal variability of fish distribution, abundance, and diversity patterns in Ouachita Mountain streams, Arkansas. Fishes and habitat were sampled quarterly for three years at 12 sites (144 samples) in the Alum Fork of the Saline River (nine sites) and Little Glazypeau Creek (three sites). The two systems are historically distinct and reflect large-scale differences in geomorphology, speciation, extinction, and dispersal. Nonmetric multidimensional scaling was used to describe the spatial and temporal variability of fish assemblages. Above and beyond a clear “historical” separation of fish faunas in the two drainage basins, assemblage structure was significantly associated with a complex environmental gradient contrasting small, hydrologically variable stream localities with larger localities characterized by more stable flow regimes. Assemblage variability was significantly associated with the environmental gradient and local species richness, such that assemblages showing the least variability were the most species-rich, and occurred in large, relatively stable environments. In the Saline River drainage, species exhibited a strong nested subset pattern and the largest, downstream-most sites contained the rarest species. Average rate of local occupancy by species was a function of their regional distribution. Thus, the more widespread a species was, the greater its local persistence. Theory suggests that species richness can be an important determinant of assemblage variability. While this holds true in our system at a reasonably small geographic scale, we suggest that spatial and temporal heterogeneity in the environment largely determines both assemblage richness and variability, thus providing a more parsimonious explanation for how stream fish assemblages are structured. The strong environmental determinants of assemblage properties and the coupling of community-wide occurrence and local persistence in our system suggest that disturbances to the natural flow regime may have predictable consequences with regard to the abundance and distribution patterns of fish species at local and regional spatial scales. This paper is in review.

Status and viability of Alabama shad (*Alosa alabamae*) in the Pascagoula River drainage. (Problem 3) Adams, with Kreiser (U of Southern Mississippi). Alabama shad are a candidate species under the U.S. Endangered Species Act. This research will provide estimates of the population size and viability in the Pascagoula River drainage and will identify freshwater habitats and characterize habitat features of importance to the species' viability. We captured juvenile Alabama shad in the Leaf, Bouie, Chickasawhay, and Pascagoula rivers from June through October 2004. Juveniles used shallow water along

sandbars or clay banks until mid-summer when they moved to deeper, faster water around large woody debris. Juveniles were much more abundant and grew faster in the Leaf River than in the Chickasawhay River. We used otoliths to back-calculate spawning times for 2003 and 2004 and are narrowing down potential spawning locations. In 2005, we will radiotag adults and track them to spawning grounds. We will assess population viability and identify life stages that contribute the most to variations in population growth rates. Identifying key life stages and habitats will provide a basis for designing effective conservation approaches and will help focus future research needs for the species. We have developed primers for determining genetic relationships among populations throughout the species' range, and have done preliminary genetic characterization of nine populations. The new information will be a vital component of a status review and listing determination. Funding is provided by NOAA Fisheries, Mississippi Department of Fish, Wildlife, and Parks, State Wildlife Initiative, and the USFS. Two graduate students at U of Southern Mississippi are currently working on the project.

Longitudinal patterns in fish distributions, densities, and demographics along the Sipsey Fork and Brushy Creek, Bankhead National Forest, Alabama. (Problem 3) Adams. Alabama National Forests funded a study examining changes in life history and population parameters of six fish species with different distributions along streams. The results will help us identify determinants of the species' distributions as well as provide some of the basic data necessary to evaluate viability of the species. Fish were collected from the Bankhead National Forest in 2000, and most demographic data have been evaluated. Final aging of otoliths is dependent on completion of otolith age validation (above). Conservation Fisheries (Knoxville, TN) raised darters for us for two years. We will examine otoliths of those known-age fish to validate age rings.

Resistance and resilience of fish communities to extended, severe drought in upper coastal plain streams. (Problem 3) Adams, Warren. During summer 2000, northern Mississippi experienced severe drought, and numerous small, perennial streams ceased flowing. We sampled 12 reaches on 8 streams multiple times to examine the rate and mechanism of fish assemblage reestablishment over one year, following the resumption of flows in November 2000. Six of the reaches ceased flowing in 2000, 5 flowed continuously, and the status of 1 was unknown. We had fish assemblage data for the reaches for 1 to 2 summers prior to drying. Fish assemblage recovery was not rapid. In 1999, the reaches contained between 5 and 25 species, but during the first post-drought sample (Nov.-Dec. 2001) none of the previously-dried streams contained more than 4 species. Over 90% of the fishes present during the first post-drought sampling were considered "tolerant" of poor water or habitat quality. Fish species and abundance accumulated slowly, with most dried reaches not recovered to their former species richness until April to November 2001. Total fish abundance peaked in June 2001 in 5 of the 7 reaches that dried. However, in all 5 of the continuously flowing streams, we measured peak fish abundances in November 2001 or 2002. Seasonal movements during spring appeared to play an important role in the recovery of species richness, whereas reproduction drove much of the recovery in total abundance. A

manuscript is in review for Transactions of the American Fisheries Society.

Spatial and temporal patterns of fish assemblages of upper Coastal Plain streams, Mississippi. (Problem 3) Adams, Warren, Haag. We assessed spatial, seasonal, and annual variation in fish assemblages over 17 months in three small, moderately to deeply incised streams with unstable sand substrates that are characteristic of northwestern Mississippi streams. We sampled 17,962 fish representing 52 species and compared assemblages within and among streams. Although annual and seasonal variability in assemblage structure was high, fish assemblages maintained characteristics unique to each stream. High variability in fish catch-per-unit-effort (CPUE) was exemplified in one site where total CPUE increased an order of magnitude from July 1993 to 1994. Species turnover and percent dissimilarity were often higher seasonally than annually, consistent with a period of change in spring to early summer and a return to similar species compositions between summers. Temporal variability was also high at the individual species level, and no species were classified as "stable". Moreover, we found no correlations among CPUE of individual species between streams and few correlations among CPUE of different species within streams. We also found little evidence for correlation between changes in fish assemblage structure and measured habitat conditions. The fish characteristics fit the profile of "colonizing assemblages", which probably resulted from both natural and anthropogenic causes. Flashy hydrographs, created in part by stream channelization and incision and watershed deforestation, may play a large role in structuring these fish assemblages. Extreme interannual variability in assemblages in the absence of detectable habitat change has important implications for the statistical power of fish monitoring programs designed to detect trends in fish assemblages over time. This study was published in *Hydrobiologia*, an international journal of stream and lake biology and ecology.

Crayfish distribution, habitat use, and life history. (Problem 3) Adams, Warren, Haag. Using data collected across the Holly Springs National Forest, Mississippi, we will begin to assess the distribution and habitat use by crayfishes. We have collected at least 10 crayfish species, including several undescribed species, on the Forest. Nothing has been published about the ecology or life history of several of the species, including the most commonly collected one, *Orconectes chickasawae*. Habitat characteristics will be summarized and related to crayfish densities at subreach, reach, and drainage scales and we will explore associations among crayfish and fish species. We are taking high quality photos of each species that will be published in a guide to the stream crayfish of the Holly Springs National Forest. We have completed nine months of a year-long life history study of several species. Preliminary genetic analyses of the *Orconectes* species we have collected suggest that four species exist where only two are described, and we are pursuing further analyses of these and additional collections. We are raising crayfish of several species at our laboratory to document timing of major life history events and to confirm specific identity of some juveniles.

Crayfish consumption of native versus non-native leaves. (Problem 3) Adams.

Preliminary experiments showed that the crayfish *Orconectes chickasawae* prefers foraging on nonnative kudzu leaves over several native plant leaves when picked green and presented in laboratory aquaria. In fall 2004, I repeated the experiment with recently fallen leaves to determine whether the pattern is maintained with leaves in a condition comparable to those typically available in streams in autumn. Crayfish preferred kudzu over some, but not all, native leaves. The results suggest that replacement of native riparian vegetation by nonnative kudzu may have implications for stream foodwebs.

Prehistoric decline in freshwater mussels coincident with the advent of maize agriculture. (Problem 3) Peacock, Haag, Warren. During late prehistory, high population densities and intensive agricultural practices of Native American societies had profound effects on the pre-Columbian landscape. However, the degree to which Native American land-use affected aquatic ecosystems is unknown. Freshwater mussels are particularly sensitive harbingers of modern-day ecosystem deterioration. We examined prehistoric trends in abundance of freshwater mussels of the genus *Epioblasma* in North America during the last 5000 years. We show that the relative abundance of *Epioblasma* declined steadily during this period. Further, the rate of decline of *Epioblasma* increased significantly after the advent of large-scale maize agriculture in the southeastern United States about 1000 years before present. Our results suggest that human land-use activities in prehistory caused changes in freshwater mussel communities that were lower in magnitude, but similar in direction to changes caused by recent activities. The paper is in review for Conservation Biology.

Spatio-temporal patterns and conservation implications of the decline of freshwater mussels in the Little South Fork Cumberland River, USA. (Problem 3) Warren and Haag. The Little South Fork Cumberland River, USA, was a globally important conservation refuge for freshwater mussels (Mollusca: Unionidae) because it supported an intact example (26 species) of the unique Cumberland River mussel fauna including imperiled species. We used previous surveys and our 1997-98 survey to reconstruct the historical fauna, describe spatio-temporal patterns of density, number of species, and persistence and evaluate the probable sequence and cause of observed mussel declines. Density and numbers of species declined steadily from 1981 to 1998, but declines occurred first in the lower river (early 1980s) followed by declines in the upper river (late 1980s to early 1990s). Lower river declines are associated with surface mining; oil extraction activities are implicated in upper river declines. Species persistence was primarily a function of pre-decline population size with only the most numerous and widespread species surviving. Of the total species recorded from the Little South Fork, 17 (65%) are apparently extirpated and 5 others appear near extirpation. The river was lost as a conservation refuge for mussels despite its remoteness, predominantly forested watershed, and several layers of ostensible statutory and regulatory environmental safeguards. The paper is slated for 2005 publication in Biodiversity and Conservation, an international journal focusing on all aspects of diversity and biological conservation.

Freshwater mussel assemblage structure in a regulated river in the Gulf Coastal Plain,

USA. (Problem 3) Haag and Warren. Freshwater mussel resources of the lower Mississippi River Basin, Gulf Coastal Plain, are severely impacted by recent human activities. Stream habitat throughout much of this region is highly altered by channelization, impoundment, effects of intensive agriculture, and catastrophic stream channel erosion. Consequently, remnant mussel communities are few and scattered. We document a diverse, reproducing mussel community (20 species) in Lower Lake, an impounded, regulated portion of the Little Tallahatchie River below Sardis Dam in Panola Co., Mississippi, USA. We identified four distinct habitat types in Lower Lake based on current and substrate characteristics, representing a gradient from habitats having lotic characteristics to lentic habitats. All four habitat types supported mussels, but habitats most resembling unimpounded, lotic situations (relatively higher current velocity and coarser substrate) had the highest mussel abundance and species density. Lentic habitats (no flow, fine substrate) were characterized by lower abundance and species density, but supported mussel assemblages distinctive from lotic habitats. Evidence of strong recent recruitment was observed for most species in the lake and was observed in all four habitat types. Although impounded and regulated, Lower Lake represents one of the few areas of stable large-stream habitat in the entire Little Tallahatchie River system. The presence of a diverse, healthy mussel community in this highly modified habitat suggests that a large component of the regional mussel fauna is relatively resilient and adaptable and is limited in the basin primarily by the absence of stable river reaches. Management actions that increase stream stability will likely result in expansion of the mussel fauna and restoration of a valuable component of ecosystem. Submitted for publication in *River Research and Applications*.

Population dynamics and demography of freshwater mussels: Application of population models and population viability analysis. (Problem 3) Haag and Warren. One of the most critical information needs for freshwater mussel conservation is an understanding of how mussel population dynamics and demographic characteristics influence long-term population viability. Validated population models are needed that will allow a quantitative assessment of how population trends are affected by changes in recruitment rate and survivorship due to habitat improvement or deterioration, augmentation of populations through captive propagation, commercial harvest, and introduction of non-native species. We are studying demographic characteristics and population dynamics of freshwater mussels at three stream sites to provide an understanding of how healthy mussel populations function. Recruitment was highly variable among species, sites, and years, but was generally strong and was a regular feature of these populations (recruits comprised 0-56% of populations). Based on stochastic simulations the average percentage of recruits in the population necessary to produce a stable population differed among species and was 11% for E. arca and 5% for P. decisum. These results indicate that the low levels of recruitment seen today in many mussel populations across the country are not sustainable situations. Survivorship from glochidia to the recruit stage was low for all species (9.12×10^{-6} - 3.92×10^{-5}). In contrast, survivorship of all other life history stages including recruits was high (average across all stages, species, sites, and years = 0.83) and varied little at any level. Populations of E. arca and P. decisum differed in their response to simulated commercial harvest: E. arca could sustain high harvest

levels of large adults, but *P. decisum* populations could sustain little if any harvest. The results of this study will be important in evaluating current status and viability of mussel populations and in formulating management plans for imperiled or exploited species. This study is ongoing. Research results have been presented at a variety of scientific meetings and a final report for 1999-2003 funding was submitted to the National Fish and Wildlife Foundation.

Using morphometrics to identify glochidia from a diverse freshwater mussel community.

(Problem 3) Haag, cooperative research with Tom Kennedy, Department of Biology, University of Alabama. Currently, it is difficult to identify larvae (glochidia) of freshwater mussels, especially in streams with diverse mussel faunas. Consequently, species-level patterns of glochidia occurrence on wild fishes or in stream drift are poorly known and represent an important information need for freshwater mussel ecology and conservation. We tested the efficacy of using three commonly and easily measured shell morphometrics to identify glochidia to species within a diverse, large-stream mussel assemblage in the Sipsey River, Alabama, USA. Using discriminant functions analysis, we were able to classify 72 % of total glochidia (n = 870) to the correct species. For individual species, percentage of correct classification ranged from 42 – 100 %. Misclassifications were a result of shell measurement overlap between some species. Despite the high percentage of misclassified glochidia for some species, the use of these three shell measurements and subsequent application of discriminant functions analysis can be a powerful and easily applied tool for identification of glochidia, even in diverse mussel communities. Paper submitted to the Journal of the North American Benthological Society.

Development of quantitative sampling and monitoring methods for freshwater mussels on southeastern National Forests (Problem 3). Haag and Warren, cooperative study with SRS-4202, Blacksburg, Virginia. USFS Region 8. Quantitative sampling for freshwater mussels has long posed a problem for ecologists and resource managers. In a series of quantitative field-based studies, we have developed repeatable sampling methods for use in evaluating questions at multiple spatial scales. We have developed methods to intensively sample stream reaches (up to approximately 25 km in length) that support significant freshwater mussel populations. This methodology is designed to estimate the population size of each species in the assemblage for use in population viability analysis, and to provide detailed information of the dispersion of each species in the reach. In 2003-2004, we completed quantitative stream mussel surveys and final reports for three streams, in the Talladega and Bankhead National Forests, Alabama, and Daniel Boone National Forest, Kentucky. We are currently assisting in design of a similar survey on the Chattooga River, Francis Marion-Sumter NF, South Carolina to take place in summer 2005.

Seasonal dry-down of intermittent streams, and its influence on fish and insect assemblages. (Problem 3) Warren with Love, Taylor. Intermittent streams are largely influenced by rainfall events which lessen during summer. As a result, flow is reduced and

riffles dry, often isolating assemblages into deeper pools which may act as refugia from drought. We investigated the consequences of this isolation on assemblages of fishes and insects (summer 2002) from tributaries of the Alum Fork of the Saline River (central Arkansas) while monitoring environmental changes associated with seasonal dry-down. The most obvious habitat change from July to September was a reduction in pool size. Concurrently, assemblages became increasingly isolated as witnessed by more frequent fish recaptures toward the end of summer. We quantified spatial and temporal variability of assemblages to examine whether variation in species composition or relative abundances was attributable to local habitat differences and/or pool position along the stream gradient. We found that fish assemblage stability was affected by changes in pool volume and pool position and that both of these variables were uncorrelated. Sites that exhibited large changes in pool volume harbored the most variable fish assemblages, and variability was higher at upstream sites. For aquatic insect assemblages, family composition varied little across sites. However, the relative proportions among families were associated with changes in water chemistry (e.g., specific conductivity). This variation was also likely related to emergence of some taxa, such as Stenonema tripunctatum (Heptageniidae) and Baetis (Baetidae), and to the increasing dominance of chironomids in pools undergoing eutrophication. We conclude that aquatic assemblages in this system, across the summer, were largely structured by variation in local habitat attributes. However, spatial position in the watershed was also important, suggesting a role for local and regional processes in structuring these assemblages.

This paper is slated for publication in *Hydrobiologia*, an international journal focusing on the biology of streams and lakes.

Ecological interactions between potential seed dispersers and Forestiera acuminata (Michaux) Poiret, swamp privet. (FS-SRS-4155-3013) Adams, Gardiner, Hamel, Burke, with Terhune (National Warmwater Aquaculture Center). During a preliminary study we determined that channel catfish are seed dispersers of swamp privet, and demonstrated that the plant employs facultative ichthyochory (dispersal by fish). We also showed that cedar waxwings are seed dispersers for the plant, and that wood ducks are seed predators. We will use our data on nutrient composition of swamp privet fruits to make an initial assessment of the importance of the fruits as an energy source for channel catfish, and to make predictions regarding other avian genera that disperse seeds. Seeds did not germinate in 2004 but we plan to continue the study in 2005.

Canopy dwelling Neotropical Migratory Warbler species and other migratory birds in Bottomland Hardwood Forest (Problem 3) *Several studies follow.* Hamel.

Measurement of Vertical Vegetation Structure in Potential Cerulean Warbler Habitat, Chickasaw NWR, Lauderdale Co., TN. (Problem 3) Hamel. Continuing collaboration with U.S. Fish and Wildlife Service at Chickasaw NWR, Lauderdale Co., TN, permitted hiring Ms. Jennifer Bulmansk, MSc candidate in Geography at the University of Memphis, to conduct a set of measurements of vertical vegetation structure in Cerulean Warbler study

grids on the Refuge. These grids are being prepared for future silvicultural treatments, and the measurements will be useful, in conjunction with existing pretreatment survey of migratory warbler use, in development, testing, and evaluation of silvicultural treatments suitable to produce habitat for migratory forest canopy warblers, particularly the Cerulean Warbler, as well as maintain healthy forest structure and composition. Preliminary results of the vegetation measurements were presented as a poster to the Society of Wetland Scientists meeting in Seattle, WA, in July 2004.

Establishment of Experimental Forest Harvest Treatments to improve Cerulean Warbler Habitat, Anderson Tully Co. lands, Desha Co., AR. (Problem 3) Hamel. Continuing collaboration with Anderson Tully Co., in Desha Co., AR, led to the establishment of the first post-harvest monitoring of Cerulean Warbler response to the treatments imposed on the Cerulean Warbler study grid in Desha Co., AR. This is believed to be the first specific forest harvest treatment designed to test silvicultural manipulations to improve habitat for Cerulean Warbler. Treatment was imposed in 2002-2004 after 10 years of pretreatment monitoring of population use of the site. Pretreatment data was used to split the plot into areas of equal previous Cerulean Warbler use. Treatments were randomly allocated to subplots. One treatment was the standard Anderson Tully Co. harvest treatment. It involved thinning the overstory to reduce mortality, improve species composition and spacing, and increase growth of the residual stand. It further involved thinning the midstory to remove poorly formed shade tolerant species in order to release advance regeneration and encourage the establishment and growth of additional shade intolerant regeneration of desirable species. The alternate treatment, a Cerulean Warbler Prescription, involved thinning the overstory to reduce mortality, improve species composition and spacing, and increase growth of the residual stand. In addition, thinning was applied in the midstory to remove poorly formed shade tolerant species in order to release advance regeneration and encourage the establishment and growth of additional shade intolerant regeneration of desirable species. Shade tolerant trees in the midstory (sugarberry, boxelder, & elm) that were good candidates for potential cerulean warbler nest trees were not cut. First year monitoring of migratory warbler community use of the tract after harvest indicated that Cerulean Warblers were using the area subjected to the Cerulean Warbler prescription for territory establishment. The results require careful following in the future, but are hopeful at this initial point. A paper on the study was prepared and will be presented at the Biennial Southern Silviculture Conference in Memphis in March 2005.

Intermediate scale distribution of Cerulean Warblers in bottomland hardwood forests. (Problem 3) Hamel. Conducted on Chickasaw NWR, Lauderdale Co., TN, the first tract-wide survey of the Refuge using stratified random sampling to test questions concerning the relationship of Cerulean Warbler and Swainson's Warbler distribution to distribution of roads, major river channels, adjacent agriculture, and distribution of Brown-headed Cowbirds on the tract. Sampling was not entirely completed, and will be continued in 2005. Initial results suggest that Cerulean Warblers on the Refuge are distinctly nonrandomly distributed, but are much more likely to be found in relatively high sites, near the Lower

Forked Deer River, almost never found within 2 km of agricultural fields, and, contrary to some thought about forest fragmentation, may not avoid roadsides on the tract. Work agrees with earlier study of distribution of the birds on Meeman Shelby Forest State Park in Shelby Co., TN, where the birds occur in distinct clumped distribution. Distribution of Cerulean Warbler differs from that of Brown-headed Cowbird on the tract.

Three-dimensional distribution of foliage in forest stands. (Problem 3) Hamel. Just about everybody would agree that vertical vegetation structure is a key to understanding distribution of birds in forests. Just how to measure that structure in a way that permits explicit depiction of habitat for different species, and permits clear measurement of vegetation for forest canopy dwelling birds, is nonetheless a thorny problem. Using a combination of techniques, including variable radius plot sampling, fixed plot sampling and measurement of individual tree crowns, as well as the use of a portable survey laser, vegetation in the Meeman Shelby Forest Cerulean Warbler study area was remeasured. Results of the measurements, when summarized, will provide a description of vegetation change on the tract, to compare with concurrent warbler community data, as well as a set of paired samples of vegetation structure made with different techniques on the same plots.

Silvicultural Characteristics of Cerulean Warbler Nest and Roost Trees. (Problem 3) Hamel. Began analysis of data on tree heights of trees chosen for nests and roost sites by Cerulean Warblers in relation to soil types and relative heights as determined with reference to FIA data. Initial contacts made with FIA personnel during the All Scientists' Meeting in Atlanta in March 2004 led to refinement of approach. Necessity to protect landowner privacy compounds the difficulty of associating individual FIA plots with specific soil types, has made it more difficult to pursue this project. When the difficulties are overcome, the approach promises to be a way to use specific information about bird habitat use at the level of the individual tree to more extensive forest management databases with the result that articulating and evaluating silvicultural treatments for songbirds in bottomland hardwood forests will be made easier.

Relationship between Cerulean Warbler geographic range and climate. (Problem 3). Hamel. Decline in populations of Cerulean Warbler may have been accompanied by a change in the range of the birds. MSc. Candidate Jennifer Bulmanski of the University of Memphis Geography Department has initiated a study that relates Breeding Bird Survey distribution of the birds to existing weather and climate data sets.

Land-Use History In Relation To Decline and Projected Recovery of the Rusty Blackbird. (Problem 3). Hamel. In collaboration with visiting researcher, Dr. Claudia Mettke-Hofmann, study of the behavioral ecology of wintering blackbirds in the Mississippi Delta was initiated in winter 2004-2004. Work will continue several more years. Collaborators will be sought in winter 2004-2005 for development of a series of studies of this species.

Sharkey Site 10 year harvest treatment preparation. (Problem 4) *Several studies follow.*

Hamel.

Response of small mammal populations to restoration of forest to abandoned agricultural lands on the Sharkey Site, Sharkey County, Mississippi. (SRS-4155-4407) (Problem 4)

Hamel. Small mammal populations, principally Hispid Cotton Rats (*Sigmodon hispidus*) and Marsh Rice Rats (*Oryzomys palustris*), with smaller numbers of House Mice (*Mus musculus*), White-footed Mice (*Peromyscus leucopus*), and Eastern Harvest Mice (*Reithrodontomys humulis*), can be very high on abandoned agricultural land during initial stages of afforestation. Preparatory to anticipated harvest of the cottonwood – oak interplanting portion of the Sharkey Site, small mammals were again monitored on 7, 448-trap grids distributed among the several afforestation treatments and subplots of the cottonwood – oak interplanting treatment, in March and November 2004. As in the past, trapping data were summarized with Program CAPTURE to derive population estimates that will form the basis for evaluating response of these animals to the treatments. For the first time, in November 2004, two Wood Rats (*Neotoma floridana*) were captured. This work will be continued through spring 2008.

Quality control tests of small mammal trapping efficacy on the Sharkey Large-scale Afforestation Experiment. (Problem 4) Hamel.

We conducted a field test in winter 2003-2004 of several alternative baits in the most populous small mammal trapping grids identified in Fall 2003, to assess the efficacy of the bait we have been using, whole oats with artificial vanilla flavoring, compared to alternative baits. Alternative baits were whole oats, whole oats with peanut oil, and whole oats with artificial almond flavoring. Initial results of that test indicate that the oats and vanilla combination is at least as effective, and probably more so, than the alternative baits employed, to capture small mammals in the treatments of the experiment. In winter 2004-2005, a similar test was conducted in which unbaited traps were set in the most populous trapping grids identified in the Fall 2004 trapping session, to assess whether the traps themselves might serve as refugia for small mammals. At this writing, the results of this test have not been fully analyzed.

Winter raptor populations and predation on small mammal populations in relation to restoration of forest to abandoned agricultural lands on the Sharkey Site, Sharkey County, Mississippi. (SRS-4155-3002) (Problem 4) Hamel.

Winter raptor counts were continued in winters 2003-2004 and 2004-2005. Because the vegetation in the several treatments is growing rapidly, it has begun to obscure the view of counters. A change in protocol was instituted in winter 2004-2005 to count only at locations that have good visibility. A concomitant evaluation of the degradation of the visibility at each of the established counting stations is being conducted in winter 2004-2005, but not complete at this writing. Presence of small mammal trapping data in this and subsequent years will permit attempts to elaborate the hypothesis that raptor numbers and small mammal populations are linked.

Winter bird populations on the Sharkey Site.I: Winter Bird Populations Studies. (SRS-4155-3???) (Problem 4) Hamel.

Continued monitoring of winter bird community use of the

several treatments of the Sharkey Large-scale Afforestation Experiment was conducted using protocols of the Winter Bird Population Study (WBPS) in winters 2003-2004 and 2004-2005.

These data will allow managers to anticipate early successional responses of birds to restoration of forest to agricultural lands. Results of the 2002 comparison between the population estimates derived by WBPS and another technique, Project Prairie Bird, designed to sample winter birds in grasslands were submitted for publication in the Journal of Field Ornithology. This work will continue annually.

Comparison of use of different afforestation treatments in the Sharkey Large-scale Afforestation Experiment by wildlife other than birds and small mammals. (Problem 4) Hamel. Using distance sampling techniques, a set of random transects was surveyed in late summer 2004 on all treatments in the Sharkey Large-scale afforestation experiment, designed to detect use of the treatments by additional animals than those already surveyed with small mammal trapping, winter bird population study, and winter raptor counts. Primary data for this study were occurrences of swamp rabbits, fire ants, and a modest number of detections of wild pigs, deer, and coyotes. Data from this examination will be analyzed with Program DISTANCE to assess differences among treatments in the responses of the different creatures.

Use of artificial nest boxes to augment density of nesting wildlife on the Sharkey Large-scale afforestation experiment. (Problem 4) Hamel and Schiff. We instituted a small experiment in 1999 and 2000 to place nest boxes in the cottonwood – oak interplanting treatment of the Sharkey Large-scale Afforestation Experiment in an attempt to develop nesting populations of cavity-dependent wildlife. Blocks were selected at random for no, moderate (2 boxes per plot), or heavy (4 boxes per plot) addition of nest boxes. Boxes have been monitored annually for use. To date, no cavity nesting birds have used the boxes. Downy Woodpeckers have been observed excavating cavities into broken cottonwood stems in all treatments since 2000. For the first time, in fall 2004, use of nest boxes by Southern Flying Squirrels was documented.

Research Accomplishments -- Process and Restoration (Problem 4)

To better understand ecosystem processes and functions within or involving bottomland hardwood communities and apply this knowledge to ecosystem management, restoration and/or maintenance at the site, region, and global levels.

Dr. Margaret Devall, Research Ecologist
Dr. Calvin Meier, Research Forester
Dr. Craig Echt, Research Geneticist
Dr. Tracy Hawkins, Research Plant Ecologist
Dr. Brian Roy Lockhart, Research Forester

A quantitative assessment of the structure and functions of bottomland hardwood ecosystems in the southern U.S. (SRS-4155-4001) Meier, Stanturf, Gardiner, Hamel. This is a long term multifaceted study centered on a portion of the minor alluvial flood plain of Iatt Creek in central Louisiana's Kisatchie National Forest. Minor alluvial bottomlands differ markedly from those of major streams (e.g., Mississippi, Cache, Red, or Missouri Rivers). Flooding is normally flashy, seldom lasting more than 3-5 days, and fluvial morphological features are spatially compressed between the incised stream channel and toe slopes of the bracketing uplands. Sediment sources are local and thus fertility commonly reflects that of adjacent uplands and upstream management practices. In the Iatt Creek study area, the forest community is dominated by a mature/over-mature sweetgum cherrybark oak overstory that is approximately 75 yrs old. An infrastructure of core measurements, descriptive information, and monitoring systems are in place. Meteorological soil water table, stream level databases are developing, and an elevational grid survey, and GPS database facilitate comparison of measurements across the 320-ha study area.

The field phases of an intensive study of plant ordination have been completed and an initial manuscript is targeted for submission in 2005. Fine litterfall has been collected, sorted by component for nearly 9 years, with leaf litterfall sorted by species for the initial three years. These materials have been composited and are now being chemically analyzed. Laboratory processing continues. Annual fine litterfall transfers, based on the initial 3 yrs of collection averaged over 8500 kg/ha/yr with leaves as the dominant single component. Variation in leaf litterfall across the study area has proven responsive to stand variables (site indices), dominant species group, and soil characteristics (fluvial morphology, alluvium depth, soil nitrogen, pH). Long term litterfall collections have been maintained to better understand if and how biological productivity and leaf production respond to variation in winter flooding/soil moisture regimes and summer droughts.

Eighth year measurements of tree mortality and growth (sapling through overstory) have also been completed and are being analyzed.

Experiments on the Ecophysiology, Ecology, Sustainability, Pathology, Population Genetics, Dispersal and Seed Biology of pondberry (Lindera melissifolia [Walt] Blume) (SRS-4155-??) Margaret Devall, Nathan Schiff, Kristina Connor, Emile Gardiner, Paul Hamel, Ted Leininger, Dan Wilson, Craig Echt, Tracy Hawkins and Brian Lockhart. *Lindera melissifolia* (pondberry) is an endangered woody plant that grows in seasonally flooded wetlands, and on the edges of sinks and ponds. It is a clonal shrub that grows to a maximum of 2 meters in height. Approximately thirty six populations are known in several

southern states. Pondberry has always been rare, and knowledge of its ecology, physiology and genetics is sparse. Also lacking is information about environmental factors required to sustain the viability of populations. The species has been affected by habitat destruction and alteration, especially timber cutting, clearing of land, and drainage or flooding of wetlands, and stem dieback is widespread. We have received a large grant from the Corps of Engineers to study ecophysiology, ecology, sustainability, pathology, population genetics, dispersal and seed biology of pondberry in order to address concerns about the survival and persistence of pondberry in the southern Mississippi Delta in view of flood control measures proposed for the region. Studies on these topics are under way.

A poster entitled 'Pondberry (*Lindera melissifolia* [Walt Blume]), one of the best-funded endangered species' was presented at the Southern Research Station All Scientists Meeting, March 3, 2004, Atlanta, GA.

An oral presentation entitled 'Studies on the endangered pondberry (*Lindera melissifolia* [Walt Blume])' was made at the IUFRO Division 1 meeting, June 12-19, 2004, Montpellier, France. An extended abstract is in press.

An oral presentation entitled 'Research on the endangered pondberry: *Lindera melissifolia* (Walt [Blume])' was given to the Biology Department, Mississippi College, Clinton, MS, 2/20/2004.

An oral presentation discussing the ecology of pondberry and describing the different parts of the pondberry study was given at the Society for Wetland Scientists conference in Seattle, Washington on July 23, 2004. An abstract was published.

A poster entitled 'An ecological study of the endangered pondberry (*Lindera melissifolia* [Walt] Blume)' was presented at the Botanical Society of America conference in Snowbird, Utah on July 29, 2004. An abstract was published

An oral presentation entitled 'Introduction of the endangered pondberry (*Lindera melissifolia*) to new sites in Mississippi' was given at the Botanical Society of America conference in Snowbird, Utah on July 30, 2004. An abstract was published.

Ecology Study: Devall, Schiff and Hawkins. Completion of forest assessment for DNF and Shelby sites [results (abstract) presented at conference in August 2004]

Permanent plots in place at DNF (10 plots), Shelby site (6 plots), Compartment 39 (1 plot). Data collection from these plots includes monitoring soil moisture content and water level, colony size, light availability, pondberry stem number and density, and stem number and density for direct competitors. Data collection began in June 2004. Study is "in progress".

Common garden study: Study initiated in September 2004. Male cloned plants (10 genotypes), female cloned plants (10 genotypes), and seedlings (6 sites) are being grown under the same conditions in the greenhouse at CBHR. Growth characteristics are being measured every four weeks. This study remains "in progress".

Potential to form a persistent seed bank: Study was initiated in December 2003. Data was collected in 2004 and will continue in 2005 and 2006. A replication of the study was initiated in December 2004. This study is "in progress".

Effect of flooding and light on interspecific competition and growth characteristics: Study was initiated in July 2004 and completed in September 2004. Data input is in progress.

Competition Study: Schiff, Devall and Hawkins. Pondberry Competition: Effect of flooding on intraspecific competition and growth characteristics. Study was initiated in December 2003 and completed in May 2004. Data analysis is in progress.

Pondberry Dispersal Studies. Several studies follow.

Fate of Pondberry [Lindera melissifolia (Walt.) Blume] Fruits. (SRS-4155-????) Hamel. To assist the Pondberry Research Team in their work on ecology and management of pondberry, a proposal was submitted to the U.S. Army Corps of Engineers to establish a protocol to videotape selected pondberry fruits from the time of ripening to their removal from the plants. The study was funded in late summer 2004, and five remote video cameras and video recorders with infrared illuminators were purchased. Because of use of existing pondberry fruits and seeds in other aspects of the larger study, only a single colony remained in the Delta National Forest with fruit when the video equipment arrived in the late fall. Constant video surveillance of that colony was initiated in early December 2004, and continued until all the fruits had disappeared from the plants, on 26 December. At this writing, the videotapes have not all been reviewed. Within the tapes that have been examined, it is clear that additional animals visited the pondberry clones than had been previously determined, but no additional dispersers have been identified.

Determination of the seed disperser(s) of Pondberry. Hamel. To assist the Pondberry Research Team in their work on ecology and management of pondberry, seeds collected from captive Louisiana Black Bear and Red Wolves were planted in pots in winter 2003 for greenhouse germination tests. Results of the germination tests were not complete at this writing. Laboratory germination of seeds defecated by a Louisiana Black Bear was about 35%, per Kristina Connor. In the field, colleagues with the Louisiana Black Bear Conservation Committee, U.S. Fish and Wildlife Service at Yazoo National Wildlife Refuge, Delta National Forest, and Mississippi Dept. of Wildlife, Fisheries, and Parks succeeded in trapping and radio-tagging two Louisiana Black Bears, one each on Yazoo NWR and Delta NF. Continued monitoring of the locations of these animals will permit clarification of the work in the videotape study above, as well as provide information on Black Bear movements

relevant to potential dispersal of pondberry.

Seed Study: Connor. In 2002/2003, we initiated storage and thermogradient table studies of pondberry seeds. From the thermogradient table study, we determined that seeds would germinate well if germination cabinets were set on a 16h light/8h dark cycle with temperatures set at 35/30°C during those cycles. We also found that the seeds store well at either +4 °C or –2 °C, even when fully hydrated. Seeds stored for 1 year still had viability in excess of 80%. In addition, we know that cold-stratifying seeds for at most 6 months, followed by warm stratification for 1 week, can result in germination in excess of 90% if seeds are of good quality.

We also found that pondberry seeds are orthodox, meaning they can be dried before storing. Experiments are currently underway to determine the best moisture content at which to store the seeds.

In 2004, we completed our analyses of the lipids of developing seeds. As expected for a member of the Lauraceae family, the seeds have a very high lauric acid content 3 months after pollination; the pulp has a very high oleic acid content.

Additionally, two major seed studies were initiated, the seed longevity study to determine persistence in the forest seed bank, and the seed persistence study, to determine the effect of environmental conditions on seed germination. In the longevity study, seeds with and without pulp were buried beneath the litter layer on a wet site. Samples were retrieved on a monthly basis and taken to the lab to test their viability. This will tell us how long pondberry seeds remain in the seed bank. In addition, we used a smaller number of seeds with the pulp intact to test differences in longevity at a wet and a dry site. In the seed persistence study, seeds were placed on the soil surface and are collected at monthly intervals to determine their viability. We have 2 months of data from these studies so far and have found that: (1) seeds without pulp have a higher % germination than seeds with pulp in both the longevity and persistence studies; thus, (2) seeds without pulp are moving out of the seed bank faster than those with pulp; (3) seeds on the soil surface move out of the seed bank faster than buried seeds; and (4) seeds on dry sites have a lower % germination than seeds on a wet site. These are very preliminary results which may change as the experiments progress,

Conservation Genetics Study: Echt. Initial results of pondberry on the Delta National Forest indicate high levels of genetic diversity with moderate barriers to gene flow (pollen and seed migration) between sites. So, while the DNF populations appear to be genetically healthy at this time we don't yet know their relative genetic diversity compared to populations in other states, or whether inbreeding is resulting in a decline in diversity over the generations. To address these important questions seed and leaf samples from additional populations on the DNF, and north in Bolivar County, have been collected, and collections are planned for populations in Arkansas, Alabama, Georgia, and South Carolina.

Ecophysiology Study: Gardiner, Leininger and Lockhart. 1) Work was completed on the

greenhouse study to determine the growth patterns of pondberry seedlings subject to low and high light availabilities. Data is currently being analyzed. A manuscript describing leaf area relationships has been drafted and is in internal review. Additional manuscripts are planned for FY 2005. 2). Work continues on the Flooding Research Facility. Construction of 36 shade houses, 84 feet long by 24 feet wide by 8 feet tall, has recently been completed. Repairs to the various water control structures have also been completed. Preparation, including placement of weed barrier on the soil surface, is underway for a late February 2005 planting of pondberry seedlings. These seedlings are currently located in the greenhouse. A manuscript describing the Flooding Research Facility has been drafted and is currently in internal review.

Large-Scale Comparison of Afforestation Techniques Commonly Used in the Lower Mississippi Alluvial Valley. (SRS-4155-4603). Stanturf, Shepard, Wilkins, Portwood, Dorris. In the LMAV, restoring bottomland hardwood forests has attracted heightened interest. This project is designed to test four reforestation techniques and includes methods outlined by both federal program guidelines and by industry. The four techniques being tested are: (1) Eastern cottonwood (*Populus deltoides*) as a nurse crop for Nuttall oak (*Quercus nuttalli*), (2) planting 1-0 bareroot Nuttall oak seedlings, (3) direct seeding Nuttall oak acorns, (4) natural, old field succession. A former farmland in Sharkey County, MS was chosen as the study area because it represents edaphic and hydrologic conditions frequently encountered in economically marginal cropland in the LMAV. A randomized complete block design was used with three replications. Block size was 32 hectares (80 acres), allowing for 8-ha (20-acre) treatment plots. All planting was completed by March 1995 and direct seeding by May 1995. The interplanted oaks were hand-planted on February 10, 1997. Sample plots have been measured in the Fall-Winter of 1995-96, 1996-97 and 1997-98. Animal damage to seedlings has also been noted. Results from the first year were published in the 1997 Proceedings of the Central Hardwood Forest Conference; third-year results were presented at the 1999 Southern Silvicultural Research Conference. Measurements have been taken annually and several publications are in progress. The principal investigators and other CBHR scientists will take growth measurements on dominant and herbaceous layer vegetation, as well as sample and measure other edaphic and biotic variables, during the 2005 growing season. Harvesting within the nurse-crop treatments following the eleventh season of cottonwood growth is planned for winter 2005. The so-called "Sharkey Research and Demonstration Site" continues to attract attention as the issues of afforestation and carbon sequestration in the Lower MS Alluvial Valley gain more prominence.

Fertigation pilot study. (FS-SRS-4155-4401) John Stanturf (SRS), Stephen Schoenholtz (OSU), Gardiner and Leininger (4155), Lisa Samuelson (Auburn). Installation of this study occurred in winter 2000. This study was set up to match (clones and treatments) a larger short-rotation study at the Savannah River Station in SC. The site at the Stoneville research station was cleared and prepared, with the assistance of the Yazoo National Wildlife Refuge and Delta Branch Experiment Station personnel. Crown Vantage (now Tembec LLC) provided cottonwood cuttings from four clones. The study is designed to examine the effects

of three levels of irrigation (no added water, low level of additional water to deliver the fertilizer, and high level of water to maintain soil moisture at field capacity), and two levels of fertilizer (none and complete). The four clones were planted in each treatment plot in a subplot design. Each treatment plot will be 0.1 acre, with cuttings planted on 3 m by 3 m spacing. This narrow spacing may require a thinning treatment at mid-rotation. Buffer areas around treatment plots will be planted as well. Every other row of trees will be removed during the fifth growing season (2003). Soil water nutrient element concentrations and root mass were measured before and after the harvest. Harvested trees were measured for biomass. Samuelson completed one season of whole stem sap flow measurements. A final harvest, following the seventh growing season, is planned for winter 2005. Whole tree volumes and fresh weights will be measured at that time.

Multiple Silvicultural Pathways of Southern Bottomland Hardwood Forests (FS-SRS-4155-XXX) Chad Oliver (Yale University), D. Skojac (SRS-4155), and E.C. Burkhardt (Vicksburg). This study was initiated by a contract to begin a study of red oak stand dynamics in the Mississippi Delta free of damage from the 1994 ice storm. The intention was to locate red oak-sweet gum stands in seven classes: old growth (no history of intervention); no cut (no intervention in last 60 years); selection cut (selectively harvested stands); seed tree/shelterwood; commercial clearcut (residual trees were non-merchantable); silvicultural clearcut (everything to a 2 inch dbh was felled); and old field (forest begun after abandonment of agriculture). We attempted to locate stands in each class throughout the Delta. One criterion for selection was that something is known of past stand history and when treatments were applied. All stands are on the protected side of the levee. We could not locate suitable stands where a seed tree cut was intentionally imposed, nor could we locate commercial clearcuts. There is only one stand in each of the old growth and old-field classes. Four “sub-studies” are conducted: census plots (now complete) where size and number of trees are recorded by species; oak plots are fewer in number and are centered on an existing oak, with age of surrounding trees determined; an age substudy where ages of all trees in a subset of the census plots are determined; and the reconstruction substudy where a detailed reconstruction of stand growth patterns is made by coring and felling trees. The following publication has resulted from this research: **Oliver C.D., Burkhardt, E.C., and Skojac, D. 200_. The increasing scarcity of red oaks in Mississippi River floodplain forests: documentation and causality.** Accepted in *Forest Ecology and Management*, final revisions are being made prior to publication.